Globelics

# Does University Reform Promote Innovation? : University-Industry Links in the Reform Era in Japan

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## 1. Introduction

A common route for the transfer and diffusion of knowledge created in universities is through publications, books and scientific meetings. Furthermore, small scale research meetings, face-to-face communication and information exchange from students and researchers based in research laboratories through the transfer of prototypes and introduction of plans is common. These can be seen as the traditional routes by which university knowledge has been spread and transferred to society. Over recent years, technology transfer from universities to industry through patents has become of increased importance.

Namely, Japan has over recent years strengthened intellectual property rights and introduced a sequence of policy changes in order to promote university-industry links. These systemic reforms have not been limited to Japan but following the lead taken by America have also been occurring in other parts of the world. Against this background, the following issues have been recognized[4]:

- It has not been sufficient for a university to bring forth intellectual property
- While faculty have enthusiasm for performing research; there has been less enthusiasm to transfer results to society
- Through the American system of using Technology Licensing Offices (TLOs) there

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[4] For instance, see Chapter 2 of the 2002 Strategic Intellectual Property Outline published by Japan Cabinet Office.

have been sufficient means to transfer technology to society

- That excellent research results can be returned to society through the acquisition of invention rights

The above points are widely recognized and shared by policy makers and those in industry, but is this really recognized as the right condition for Japan? Furthermore, as university faculty acquires new knowledge about patenting, what is the relationship with the traditional role of publishing research results as quickly as possible by academic faculty? In this paper, engineering and bio-science faculty within the University of Tokyo will be the subject of analysis for assessing the compatibility of research activities between faculty and industry and faculty participation in scientific publications and patenting. To reflect growing international interest in university-industry links, a series of research studies have explored university faculty scientific publication and patent acquisition in collaboration with industry to assess the types of relationship between research and innovation. Representative research performed on European and American faculty will firstly be introduced.

In the United States, detailed analytical work by Agrawal and Henderson (2002) has elucidated university-industry links, research activities, and the role of intellectual property, spin-offs, scientific publications and patenting for university faculty at the Massachusetts Institute of Technology (MIT). According to the results of this study, it was found that over a period of ten years university faculty attached to mechanical and electrical engineering departments at MIT have at most only one patent acquisition, which is significantly less per person than the number of publications. And as for the relationship between the number of patents and publications produced by similar faculty, a correlation is difficult to observe. Furthermore, to observe intellectual property spin-off patterns, the details of faculty who hold collaborative relations with private companies will be investigated; with faculty and patents, there is generally no overlap between scientific publications with collaborative companies and the number of scientific publications, suggesting that specialist companies tend to have relations with universities.

On the other hand, with regard to the activities of faculty in European Universities, analytical research on the relationship of both research activities and patent applications by Italian University faculty has been performed (Breschi et al. 2005). In comparison to the United States, faculty participation in patenting at Italian universities is small. Furthermore, according to panel data analysis of the relationship between patent and scientific publication productivity amongst faculty, a positive correlation was observed. Amongst Italian faculty that have become inventors and applied for patents, in 75% of

cases the rights to the acquired patents have belonged to industry and most faculty patents have been the result of contract research through collaboration with industry. From this fact, as a result of contract research and resources from industry, the scientific research productivity of faculty at Italian universities has increased. On the other hand, if company patent applications are observed, it is surmised that through university collaboration the production of patents has also increased.

In addition, with regard to other related studies, early pioneering research investigated knowledge spillovers from American universities to regional companies using patent data (Jaffe 1989); following the Bayh-Dole Act, analysis using patent citation data suggested that there was deterioration in patent quality (Henderson et al. 1998); where licenses were granted to the private sector from universities that were immature at patenting, research found that providing incentives for researchers was of importance (Jensen and Thursby 1998) and was discovered as the source of increased university licensing in some research (Thursby and Thursby 2000). Following the Bayh-Dole Act, reasons for the deteriorating quality of university inventor patent citations were observed (Mowery and Ziedonis 2002), and the links between patent citations to the scientific literature were investigated (Branstetter 2004), amongst other numerous studies.

The results of these studies suggest that university faculty engagement in university-industry research activity is diverse with knowledge transfer between universities and industry complex and not easily explained in a simple model. Also, the research introduced above in America and Italy, even within the same university has shown that for faculty the frameworks, values, and background as well as the substance differ. The activities of university faculty in each national innovation system have a distinctive history and background and it must be recognized that it is not easy to introduce guidance and systems from one country into another country. In this paper, the period from 1990 to the beginning of the 21$^{st}$ century will be the subject of discussion. The particular cases of university faculty research activities and university-industry links will be elucidated. In sum, this paper will look at the production of patenting and publications by academic faculty and assess through bibliometric measurement the characteristics of university-industry links in Japan in comparison to Europe and the United States.

## 2. Analytical Method: Creation of the University of Tokyo Faculty Publication and Patent Database

We constructed the database that covers the period 1991-2002 and includes faculties attached to engineering and bio-science departments at the University of Tokyo on 1 April 2002. Those employed at professor and associate professor levels for a period of more than two years are the subject of the study. As presented in Table 1, this includes 392 engineering and 346 bio-science researchers[5]. Professors that had retired before 2001 and that had newly registered after 2002 were not included. In order to compare with the MIT study mentioned above, this study excludes lecturers, assistants, academic guests and part-time workers, and counts only those employed concurrently. In the MIT survey, electrical and engineering faculties were included and for this study, 83 of the 392 engineering faculty have specialized in electronic, electrical and mechanical research. Concerning each of these faculties, their affiliation for each academic year, full name in English and Japanese and address were entered into a database. If the year of affiliation is looked at for each discipline, amongst the engineering faculty around 50-60% held an affiliation of 10 years; with bio-science researchers the ratio of affiliation over a 10 year period was lower in comparison to that of the engineering faculty. For each discipline and for each year, there is a substitution of around 5-6% faculty.

Concerning scientific publications, the Institutional Citation Report by Thomson Scientific was purchased from which to match the addresses of faculty located from the above database. For each year the number of publications and citations were extracted. The study period covered is 10 years. In the case of publications, this is the year of submission from 1991 to 2000; matching the affiliation over the 1991 to 2000 period. Furthermore, these articles and data on collaborative partners were aggregated by sector, with the university-industry-government sector aggregated separately. The analytical purpose of this chapter is for grasping the quantitative nature of University of Tokyo faculty engagement with industry through the particular cases of university faculty. For that purpose, one joint paper is counted as equaling one relationship count[6].

Table 1: The number of faculties investigated by fields

[5] Engineering faculty includes those at the Research Center for Advanced Science and Technology (RCAST) and the Institute of Industrial Science and including those that had retired, the total number was 1,916. Bio-related and science sections, and medical, pharmaceutical, and agricultural sections, medical research facilities included; retiree and attached faculty total 1,623.

[6] In the case where there was more than one author, each author was counted as 1; a partial count and division of the coefficient with multi-author papers was not performed.

| | |
|---|---|
| Electronic, electrical, information systems | 37 |
| Mechanical, precision machinery | 46 |
| Aeronautics, ship, nuclear | 43 |
| Chemistry, materials, applied pfysics | 103 |
| Civil engineering, architecture | 60 |
| Research Center for Advanced Science and Technology | 27 |
| Institute of Industrial Science | 76 |
| Engineering total | 392 |

| | |
|---|---|
| Biological sciences | 54 |
| Medicine | 40 |
| Pharmaceutical | 33 |
| Agriculture | 168 |
| Institute of Medical Science | 51 |
| Bio-science total | 346 |

*The names of fields are as of 2002

Regarding patents, a publicly available CD-ROM from the Japan Patent Office was obtained. From this the "inventor name", "applicant" column, "full name" and "residency (city/town/village)" was matched with the University of Tokyo faculty database outlined above. For each year within the 1991-2000 periods, applications by the attached faculty were extracted. For the period of study, the year of patent application and the year of scientific paper submission were regarded as the same, and in the case of scientific paper the time window was adjusted by adding one year for publication. Also, the names of applicants were collected and listed by six types: individual, private company, President of the University of Tokyo, the Japan Science and Technology Agency (JST), The Advanced Science and Technology Incubation Center (CASTI[7]), and public organizations. The reason for counting JST and CASTI in addition to the President of the University of Tokyo is that until recently these have been recognized formally as patent holders for the University of Tokyo. Similar to the reason with scientific publications, in the case of multiple inventors listed on patents, a partial

[7] The Advanced Science and Technology Incubation Center (private company), was the first TLO to be recognized by the Ministry of Economy, Trade and Industry and the Ministry of Education, Culture, Sports, Science and Technology. Tokyo University TLO was established as an independent private company of the University of Tokyo in 1998, but from 2004 when Tokyo University became an independent corporation, the company name changed to Toudai TLO (private company).

count was not performed.

## 3. Analysis of Scientific Publications and Patents by Tokyo University Faculty

### 3.1 The Case of Scientific Publications

As presented in Figure 1, the histogram shows the total number of scientific publications for faculty on a per person basis in the engineering and bio-science fields over a ten year period. Through simple comparison with the MIT study, two types within the engineering field including *all engineering*, and *electrical, electronic and mechanical* engineering were aggregated. On a per person basis the number of publications has broadened its distribution, and over a ten year period there are researchers recorded as not having published (electrical, electronic and mechaninal engineering is 12%; total engineering 17%; bio-science 16%); on the other hand at the maximum there are some faculty with 304 publications recorded. In the case of the MIT study, a histogram shows the total publications over a 15 year period and there is a group of researchers with more than 35 publications. In the case of this Japanese study, there was a group of faculty with more than 24 publications for a 10 year period. Looking at the component distribution of the largest publication groups, at MIT around 14% of faculty belong to this group. By contrast, amongst the engineering faculty at the University of Tokyo this is around 32% (Bio-science faculty around 9%), and with electrical and electronic engineering around 23% of faculty belong to this group. This is large in comparison to MIT. Of course, it is natural that for each research field differences are accorded to scientific publications. There are fields where faculty performance is evaluated directly in relation to the number of scientific publications; there are other fields where scientific blueprints and plans are of greater importance. It should be recognized that this has a big influence on the differences between fields.

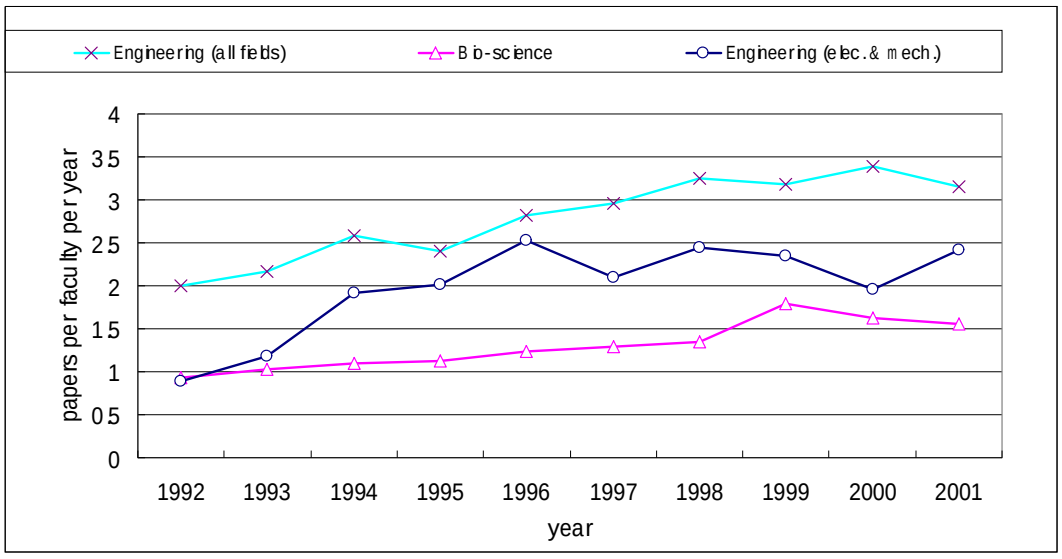


Figure 1: The number of paper publications per faculty at the University of Tokyo

In Figure 1, total publications are calculated for each year with the exception of enrolled faculty, and the average publication trends on a per person basis. Although Figure 1 is based on the average score and shows that the number of publications per person has increased significantly, how much meaning should be attached to this requires some prudence[8]. Leaving this point to one side for the time being, if electrical, electronic and mechanical engineering are compared, on average the number of publications by faculty at the University of Tokyo are not at an inferior level to those from faculty at MIT[9]. As mentioned earlier, this data draws on the database provided by Thomson Scientific and the focus of this database is English language publications. If this is considered, the number of publications by University of Tokyo faculty may in reality be larger than the figure presented here. Namely, if publications in electrical and electronic engineering including those that are not only published in the English language are compared, it may be suggested that the average number of publications per person by University of Tokyo faculty are greater than MIT faculty. The number of publications per person in the bio-science field is a lot smaller than that for the engineering faculty. With increases in the number of publications per person and the number of publications per year, in reality the reasons why productivity has increased at

[8] The distribution of the number of publication per person is highly skewed to the left. Concerning the statistical characteristics of skewed data, rather than using the mean value the median value is more appropriate in a number of cases. However, the MIT data are presented and compared using the mean value.

[9] The MIT study shows that the average numbers of publications per person per year were between 1.5 and 2.0 from 1983 to 1997.

the University of Tokyo are not clear. Specifically, this may be because the number of Thomson Scientific core registered journals has increased[10]; it may also be possible that the number of authors per article have increased. Also if you observe the faculties as a whole, more than 60-70% of faculties produce more than 1 publication per year (Figure 2). This is almost the same ratio as at MIT according to Agrawal et al 2002, and at both universities, the deviation on this ratio is small, and there is also little difference by year.

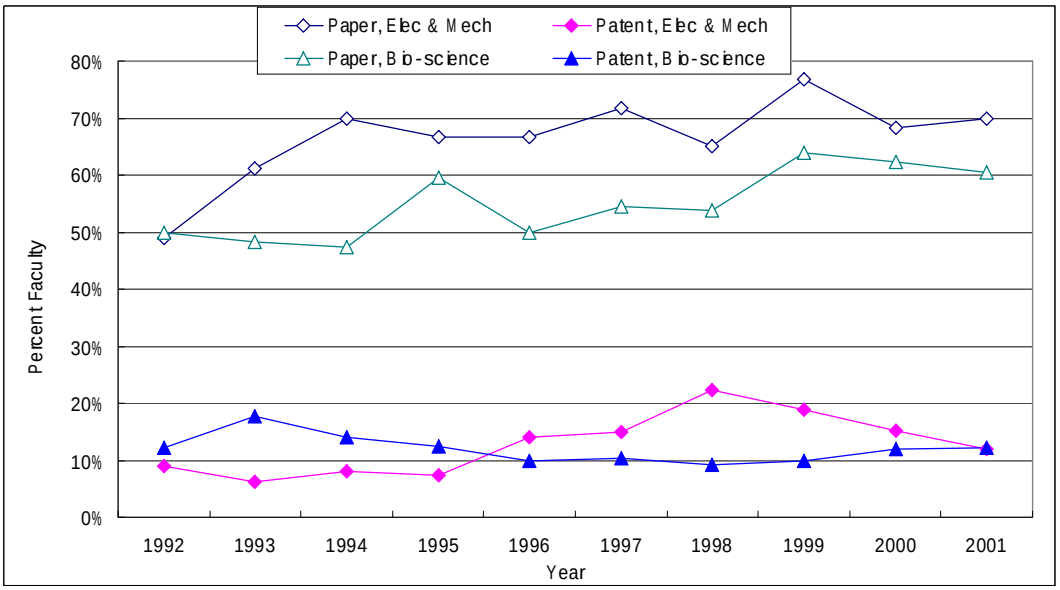


Figure 2: The ratio of faculty that produces more than 1 publication or patent per year

There are various theories about how scientific publications should be evaluated. Firstly, whether the quality of the paper or only the number of publications should be valid is one issue. For the analysis in this paper, the number of publications (log value) and the expected citation rates (log value) are investigated[11]. In that respect, the citation rate for the engineering faculty is 0.83, and with bio-science a little less at 0.50 (significant at the 1% level); consequently, for faculty professors at the University of Tokyo the relationship between the quality and quantity of publications is not substitutive, and

[10] Currently, regarding scientific journals published throughout the world, according to Ulrich's Periodicals Directory (R.R. Bowker) there are around 22,000 journals, but the core journals covered by the Thomson Scientific database for 2005 were are around 8,700.

[11] The "expected citation ratio" provided by Thomson Scientific is the weighted average of impact factors of the journals in which articles are published. Although Journal impact factors do not always ensure the individual citation frequency, we confirmed that the expected and the realized citation ratio is highly correlated (r=0.89) for faculty with 10-year affiliation.

there tends to be a relationship where both a large quantity as well as quality can be observed. Scientific publications may be a reasonable indicator for measuring the creation of intellectual property.

### 3.2 The Case of Patents

The Annual Report of the Japan Patent Office provides the number of 'university inventions'. However, it counts only for the officially recognized patents those belong to the universities, JST and TLOs. To clarify the total number of patents generated by university researchers, the University of Tokyo faculty (including Professor, Associate Professor, Lecturer, Assistant, including retired faculty) register of names with addresses in the official published patent bulletin and the number of names of University of Tokyo faculty over the ten year period (1991-2000) were observed. For engineering, 2,049 applications by University of Tokyo faculty were located, and for bio-science, 582 applications were located. For the majority of these patents, applicants were private companies with some patents jointly applied for with faculty. Joint applications for the engineering faculty were 759 cases; and in the case of bio-science were 142 cases. Also, for the President of the University of Tokyo, there were 58 applications for engineering patents, and 10 bio-science applications; for JST, 114 patent applications for engineering, and 125 applications in bio-science; for CASTI (cooperative), 15 engineering cases; and 4 bio-science cases were observed[12].

Until now, for formally announced patents for the University of Tokyo are equal the sum of those for the University of Tokyo President[13], JST and CASTI, for engineering this was 186 cases, and 132 cases for bio-science. This research found that the formally announced number of university patents only makes up a small part of those patents faculty participating in actual, for engineering this was 9.1%; for bio-science 22.7% of the total.

[12] There were no cases of duplicate applications between the President of the University of Tokyo and the JST as well as the private sector and the Advanced Science and Technology Incubation Center (joint applications) in the case of bio at CASTI and the President of the University of Tokyo, there were only two joint applications.

[13] The University of Tokyo homepage, Japan Patent Office Annual Report, Asahi Shinbun Company (University Ranking), the Ministry of Education, Culture, Sports, Science and Technology (University industry relations: Research Survey and Committee on Cooperation and Ways of Operation), March 1998 etc.

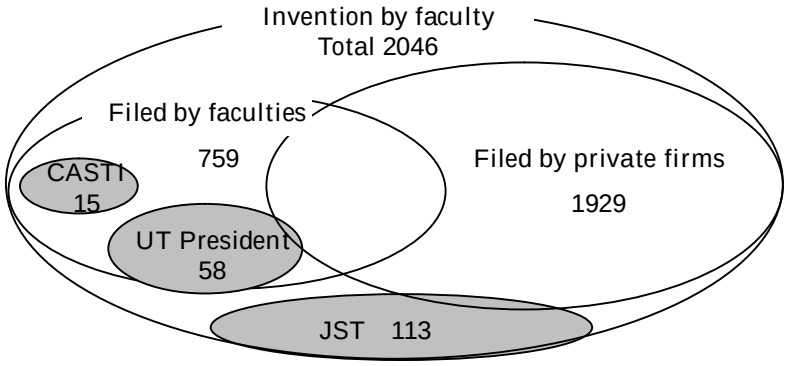


Fig. 3: Patent applicants for UT faculty's inventions

Amongst 2,046 engineering patents over the ten year period covering 1991-2000, Professors and Associate Professors within our scope of analysis produced 1,119 patents. Similarly, for the bio-science patents, 379 out of 582 patents were from Professors and Associate Professors within our scope. In a number of cases individual applications were found, but the number of faculty who have jointly developed a patent are more numerous. In this case, for those patents for each member of faculty a count of 1 was made[14]. For this reason, for each faculty the total number of faculty increased from 1,119 cases to 1,334 cases; in the case of bio-science from 379 cases to 406 cases. Of the engineering patents, 738 cases out of 1,119 were applied by total of 247 private companies. For bio-science patents, of 379 cases 253 were applied by total of 126 private companies.

If we observe a histogram which shows the number of patent applications for University of Tokyo faculty in engineering (Electrical and Electronic engineering) and bio-science related research, the number of patent applications scatters widely likewise the number of publications, but the number of faculty not related to patents for 10 years goes up to 65% for engineering, 71% for bio-science research, and 58% for electronics and electrical engineering (data not shown). The ratio for the faculty without any patent is far greater than for scientific publication. Although the analysis period for MIT study is 15 years and that for the University of Tokyo is 10 years means that ratio cannot be compared directly, it is possible that the majority of the faculty of the University of Tokyo is not involved in patenting activity as is also the case in MIT. In Figure 4, for each year changes in the total number of patent claims[15] per faculty at the University of

[14] This count method was also employed in the MIT survey.

[15] In 1998 the Japan Patent Office introduced a new system for the improvement of multiple claims; until then the general principle had operated under a system where one application per one claim could be

Tokyo are compared between fields. On a per person basis, the total number of claims for each year are scattered widely and for the engineering faculty this is neither up nor down. Similarly, even for individual faculty at the University of Tokyo the number of patent applications for each year is about 0.5 and has not changed significantly (data not shown). As observed above, the index for scientific publications at MIT and the University of Tokyo has increased, although it is important to heed that the kind of patent index available for University of Tokyo and MIT are not identical, yet the changes in patenting activity can not be observed at the both universities.

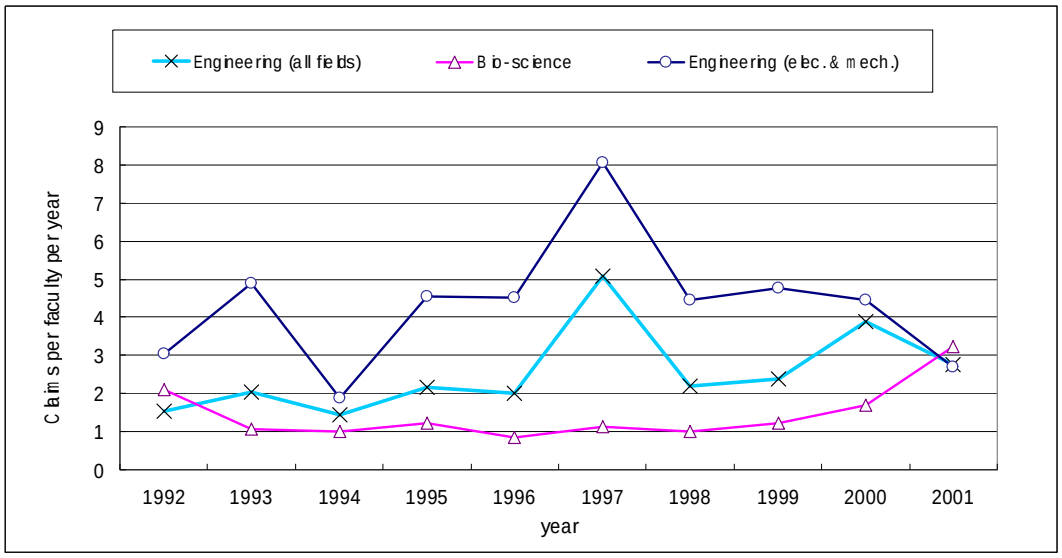


Figure 4: The number of patent claims per faculty at the University of Tokyo

made. As a result, the number of patent applications did not increase dramatically, however, per application, the number of claims increased gradually. If the number of applications and the number of claims are observed on an annual basis, then over the 1990s there was a continuous increase. How the "unit of invention" should this be considered, however, following the system reforms there was a large influence on the application and claim numbers and it may be rational to utilize the number of claims in addition to the number of applications.

Figure 2 also draws on the University of Tokyo database to observe the ratio of faculty related to patents. As has been observed, within a one year period the ratio of faculty with more than one case of publishing a scientific publication at the University of Tokyo is 60-70%; meanwhile the ratio of faculty related to patenting is only 10-20%. In the case of Japan, the number of patent registrations per application is about one in four, so the ratio of faculty associated with patent registrations should be smaller than that of MIT (MIT study reported that ratio as about 15%). Using this quantitative view, a large difference can be observed between the share of intellectual property and creation of patenting and publication activity by university faculty. Similar to MIT faculty, the majority of faculty at the University of Tokyo is not involved in patenting.

### 3.3 The Relationship between Scientific Publications and Patents

Based on the above, where the average rates for various faculties have been analyzed, large differences were observed between the reality of individual faculty publication of scientific articles and patent applications. Here the relationship between patent applications and scientific publication activity will be analyzed at the level of the individual academic unit. At this level, the scatter diagram in Figure 5 shows the average number of publications and patent applications over a ten year period. It appears that there is a positive correlation between the number of publications and the number of patent applications; however, five researchers involved in engineering type research and one in six researchers in bio-science related research have an extreme influence on the total pattern. With the exception of these 5 engineering faculty, the dependent variable will be the number of patent applications, while the independent variables will be the number of publications, the number of publication citations, and the number of publication and patenting collaboration with private companies, will be used in a multivariable regression. With respect to the bio-science related researchers, in comparison to those involved in engineering, the number of patents and joint publications are small so these cases have been excluded from the analysis.

In Table 2 the OLS estimation results for the variables are presented. Although a weakly significant positive relationship can be observed between the number of patent applications and publications, with publication citation rates a relationship is not observable. Also, a positive relationship can be seen between the number of papers jointly authored with industry and the number of patent applications. Testing the independent variables for multicollinearity, the VIF value suggests that there is generally no problem with the range. In interpreting these results, those faculty that

publish a lot of publications appear to have a lot of patents; especially, those faculty that jointly publish papers with private companies and engage in patenting activities with companies are those create a lot of patents. Witnessing this tendency, there is a large integrative effect between University of Tokyo faculty that perform joint publications and joint patent applications in cooperation with companies. If this point is considered further, it may be possible that resources and sponsored programs from industry have a contributory effect on the research activity of university faculty.

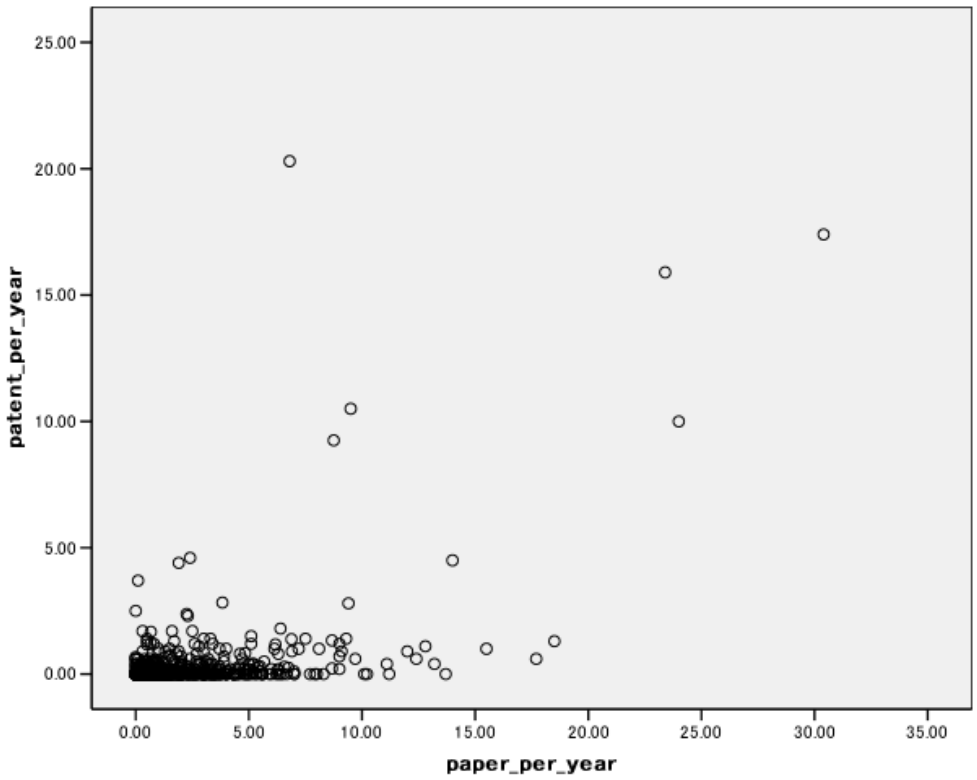


Figure 5: the average number of publications and patent applications per faculty

Table 2: OLS estimation of the determinants of the number of applications

Dependent variable: log_applications

| variables | coefficients | t | VIF |
|---|---|---|---|
| log_papers | 0.052 | ( 2.31 ) * | 2.44 |
| log_impact_factor | 0.002 | ( 0.27 ) | 1.53 |
| log_coauthors | 0.082 | ( 1.99 ) * | 1.81 |
| log_copatents | 1.366 | ( 22.75 ) ** | 1.12 |
| department dammy | (yes) | | |
| (Constant) | -0.005 | ( -0.32 ) | |
| Adj. R_squared | 0.683 | | |
| Observations | 316 | | |

*5% Significant, **1% Significant

## 4. Research Activities and the Relationship with University-Industry Links

From the analysis of University of Tokyo faculty scientific publications and patenting, the research activities of university faculty in Japan and industrial relationship activities have been clarified. In reality, since 1983 with the introduction of a collaborative system for national universities and companies, at the University of Tokyo the number of collaborative research cases, with particular attention on relations with big companies, increased from 90 cases in 1992 to 100 cases in 1995; by 1997 this had surpassed 150 cases and since the systematic reform, the number of cases has increased rapidly and surpassed 300 cases in 2001 (NISTEP 2003). As collaborative research is one of the representative aspects of university-industry links, it can be thought that its development may have an influence on research activities. In this section, university research activities and participation in university-industry links will be clarified on a quantitative basis through observation of University of Tokyo faculty and company researcher publications and joint publications.

Over a ten year periods the total number of publications registered in Thomson Scientific Database for University of Tokyo engineering faculty is 9,748; over the same period the number of publications for bio-science related researchers is 3,718 publications. To observe joint publications, the distribution of authors and addresses

were reviewed and it was found that the mode value, namely the most frequently observed, of the number authors is three people. The next is four and five joint authors; single authorship in the case of engineering faculty is around 3% and for the bio-science faculty around 9%. On the other hand, with the number of address citations in each scientific publication, the case where authors do not mention their addresses is numerous, but there are also a lot of cases where authors have mentioned two addresses. Next, this research sought to draw out per person the number of joint publications by University of Tokyo faculty in engineering and bio-science and the specific addresses, joint author affiliations and investigate the changes over time. As for the attributes of the authors addresses, six categories were located ((UT: internal), (other university), (government organization), (private company), (non-profit organization), (foreign organization)).

In Figure 6 the results of this research are presented. If the breakdown by joint affiliation is observed, the most overwhelming point is that the ratio of collaboration within the university for the engineering faculties has decreased from 70% in 1992 to 60% in 2001; for bio-science related research this is similar with a slow decrease from 70% to 50%. Also the ratio of private companies stood at 10% for the engineering faculty in 1992 decreasing to 5% in 2001. For the bio-science faculty, the ratio for joint publication with private companies was not even 2% but for 2001 had increased to 3%. On the other hand, for other universities, government research labs and overseas organizations the ratio of joint publications has increased, the area where this growth is most remarkable is in joint publications with government research laboratories and semi-governmental corporations. For joint publications for each faculty member, in total the number of joint publications has increased, excepting with private companies. For engineering this is 0.4 cases on an annual basis; in the case of bio-science this is 0.1 to 0.2 cases on an annual basis; over a ten year period then there has not been a significant change. Looking at the above total in order to grasp the cases of formal collaboration at the University of Tokyo, these have increased significantly since the 1990s. To join together the results and the number of publications at the present time, the increased formal collaboration with private companies has not yet had a significant impact on the number of joint publications as a whole.

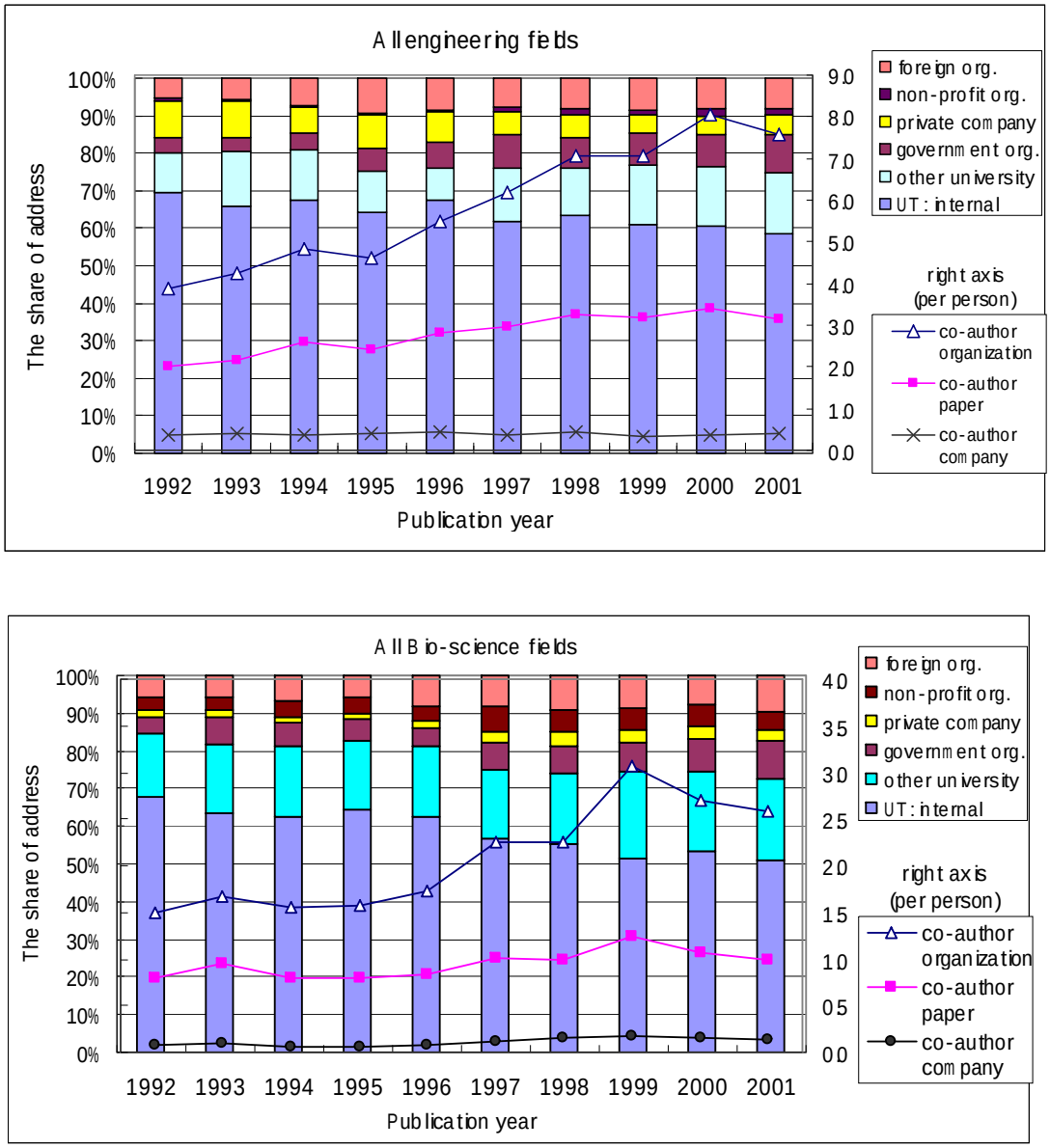


Figure 6: Partners of the co-authored publications and per person counts

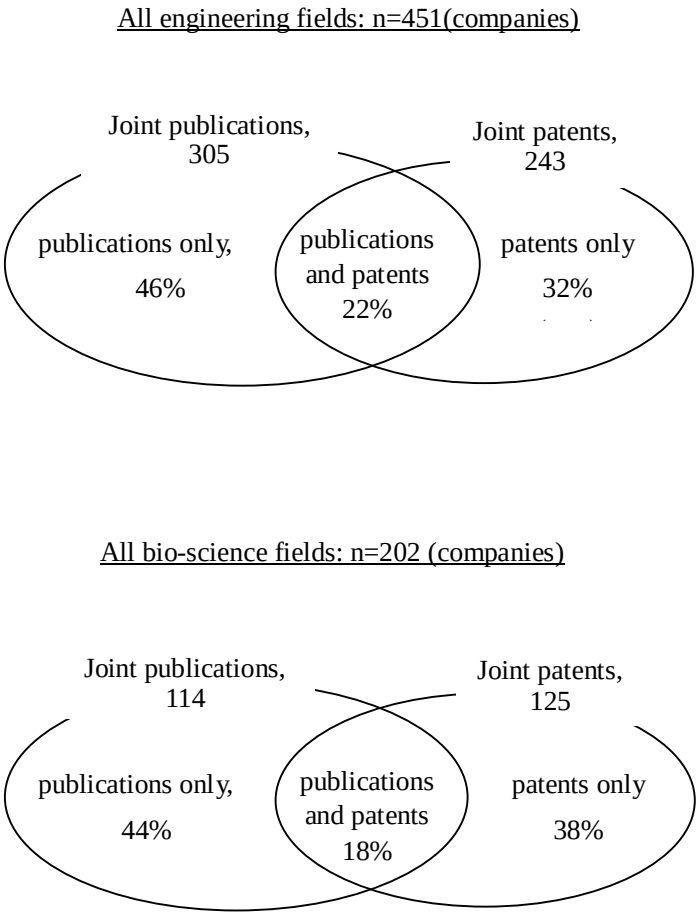


Figure 7: The types of collaboration with the University of Tokyo

Next, the unit of analysis is set to private company and the research will now look at joint publications between university faculty and private industry and joint patenting applications. In engineering related fields, the number of collaborative papers is with 305 companies, for patent applications 243 companies. With bio-science faculty, the latter is exceeding the former. In Figure 9 the results are presented which show the number of companies that have only joint publications with engineering related faculty, which is 208 companies (46%); that have only joint patent applications, 146 companies (32%); and that for those companies that produced both joint publications and joint patent applications (97 companies, 22%). For bio-science related faculty this does not change greatly. 88 companies (44%), 77 companies (38%), 37 companies (18%) respectively. Comparatively, if the data from the MIT study are reviewed, the number of companies that jointly created publications and patents with MIT faculty in total

includes a small number of around 3% (Agrawal and Henderson 2002). According to the data, comparatively the differences between Japan and America are large; with it being observed that in comparison to America, there is a two-way trend for joint publications and patents between Japanese university faculty and companies. Furthermore, this research has observed the aggregate number and distribution of joint publications and joint patent applications for each company and University of Tokyo faculty. In the case where the company side was observed, the number of joint publications written with University of Tokyo faculty and the number of joint applications with University of Tokyo faculty was not clearly correlated.

Finally, over the ten year period joint patent applications and publications in sum by each company is ranked by the top 20 companies. In Table 3, both sides are displayed. Meanwhile, the company with the most joint publications is TOSHIBA CO LTD (64 publications) and it has only 8 joint patents; the company with the most joint patent applications (71 patents) is the NIPPON OIL CO LTD and it has only one joint publication.

## 5. Conclusion

We have illustrated the truth of university-industry links using a series of data for UT faculty from before the reform era to the end of the 1990s. It is obvious that the faculty had been vigorously engaged in university-industry links even before the reform era. For the invention activities of the faculty at UT, the number of inventions those had been filed through private firms in collaboration was revealed to be quite large and greater than what was ever grasped formally. As for this fact, among first rate research universities in US such as Stanford University or Carnegie Mellon University also have long history of university-industry links before the introduction of the Bayh-Dole Act passed in 1980. Our finding coincides and agrees with the cases in US (Mowery et al. 2001).

Table 3: The list of companies collaborated with the University of Tokyo

| rank | Publications | Patents | Company |
|---|---|---|---|
| 1 | 64 | 8 | TOSHIBA CO LTD |
| 2 | 62 | 5 | HITACHI LTD |
| 3 | 60 | 5 | NIPPON TELEGRAPH & TEL PUBL CORP |
| 4 | 38 | 10 | NIPPON STEEL CORP LTD |
| 5 | 37 | 0 | ELECT POWER DEV CO LTD |
| 6 | 30 | 5 | MITSUBISHI HEAVY IND CO LTD |
| 7 | 29 | 6 | NEC CORP LTD |
| 8 | 20 | 9 | FUJITSU LTD |
| 9 | 19 | 0 | IBM CORP |
| 10 | 18 | 1 | SUMITOMO MET IND LTD |
| 11 | 17 | 7 | ISHIKAWAJIMA HARIMA HEAVY IND CO LTD |
| 11 | 17 | 2 | OKI ELECT IND CO LTD |
| 13 | 16 | 1 | MITSUBISHI ELECTR CORP |
| 14 | 15 | 3 | MATSUSHITA ELECT IND CO LTD |
| 15 | 14 | 12 | ASAHI GLASS CO LTD |
| 15 | 14 | 24 | EBARA CORP |
| 17 | 13 | 10 | MITSUBISHI CHEM CORP |
| 17 | 13 | 20 | TOTO LTD |
| 19 | 12 | 1 | OBAYASHI CORP |
| 20 | 11 | 1 | NIKON INC |
| 20 | 11 | 1 | NISSAN MOTOR CO LTD |
| 20 | 11 | 5 | TOKYO ELECT POWER CO LTD |

*Rank order by the number of joint publications

| rank | Patents | Publications | Company |
|---|---|---|---|
| 1 | 71 | 1 | NIPPON OIL CO LTD |
| 2 | 39 | 0 | TOSHIBA MACHINE CO LTD |
| 3 | 24 | 14 | EBARA CORP |
| 4 | 23 | 0 | RICOH CO LTD |
| 5 | 21 | 0 | SEKISUI CHEMICAL CO LTD |
| 6 | 20 | 13 | TOTO LTD |
| 7 | 18 | 1 | MEIDENSHA CORP |
| 8 | 15 | 4 | UBE IND LTD |
| 8 | 15 | 0 | YKK CORP |
| 10 | 14 | 10 | ISHIHARA SANGYO KAISHA LTD |
| 11 | 12 | 14 | ASAHI GLASS CO LTD |
| 11 | 12 | 3 | FANUC LTD |
| 11 | 12 | 0 | MUNEKATA CO LTD |
| 14 | 11 | 3 | OPT MEASUREMENT TECHNOL DEV CO LTD |
| 14 | 11 | 4 | SUMITOMO HEAVY IND LTD |
| 14 | 11 | 0 | TEIJIN LTD |
| 17 | 10 | 13 | MITSUBISHI CHEM CORP |
| 17 | 10 | 38 | NIPPON STEEL CORP LTD |
| 17 | 10 | 7 | NKK CORP |
| 17 | 10 | 4 | OYOKODEN LAB CO LTD |
| 17 | 10 | 2 | SUMITOMO CHEM CO LTD |
| 17 | 10 | 10 | TOKYO GAS CO LTD |
| 17 | 10 | 0 | CASTI |
| 17 | 10 | 0 | MITSUI CHEMICALS INC |
| 17 | 10 | 0 | POLYPLASTICS CO LTD |
| 17 | 10 | 0 | TOYOTA INDUSTRIES CORP |

*Rank order by the number of joint patents

However, similar to the case of MIT, we have shown at a quantitative level that for

University of Tokyo researchers, the creation of patents in comparison to publications is very limited. In addition, although the University of Tokyo's activities in collaborative research projects with private companies have increased rapidly according to the official data, it is not reflected in the number of patents produced by the faculty. Based on this, despite the strengthening of intellectual property rights at universities and the establishment of TLOs, the organizational ownership of intellectual property and the series of system reforms, in Japan it is too naive to surmise that incentives change has occurred ubiquitously[16]. Nelson, one of the leading innovation researchers, has observed that it is a widely believed myth that the acquisition of university patents has been a key to the acceleration of innovation over recent years[17].

In order to observe the relationships between faculty research activity and invention, we have explored the relationship between publications by university faculty and patent productivity. From this, with the exclusion of one group of researchers who are at the extreme in terms of performing a lot of inventions, the degree of significance for publications and patents was recognized as weakly positive. However, the hypothesis that the superior researchers who get a lot of publication citations participate in more patents could not be recognized as true. But it must be noted that the researchers who frequently produce publications and patents with corporate researchers or with various companies contribute to the development of a lot of patents. The last finding appears to be consistent with the results from company side analysis, that is a certain part of companies collaborating with the University of Tokyo faculty are involved in both joint publications and joint patents. Also, the main incentive for university-industry links has not been the financial return but the acquisition of research funds for the purpose of research (Walsh et al, 2006). In consideration of the above point, conventional university-industry links for university faculty has been through a wide range of choices,

[16] In general, publicly available data on universities and TLOs from the latter half on the 1990s to this decade shows that university patenting has increased, and it is apparent that the patent applications through companies have shifted to formal patent applications by universities and patent productivity seems to have increased. Also, over this period the Science and Technology Basic Plan was introduced in Japan, and the research environment and facilities at universities through public research funds improved significantly.

[17] Presentation at the Research Institute for Economy, Trade and Industry, RIETI Policy Symposium "System Design of University-Industry Co-operation", December 11, 2001, http://www.rieti.go.jp /en/events/01121101/nelson.pdf
In addition, Hodges at the University of California, Berkeley, noted that with bio-science, agriculture and medical supplies, the process of creating a product is extensive and long term and the product life span with a monopolistic position can be maintained. For university patent acquisition security, technology transfer plus labor in comparison to other fields, especially computers and electrical engineering and software, where business leadership is strong, the contribution of patents is likely to be limited with there is likely to be a largely negative impact on the contribution to industry. For Hodges, the functions of the university by nature are the production and diffusion of knowledge and any barriers to this are likely to be dangerous; Hodges proposed that university-industry links and joint project results should be made public goods.

where university faculty have received research resources from companies that have accelerated research activities; on the other hand, there also were some researchers who do not care about collaboration with industry.

The conventional system for university-industry links before reform era had been emphasizing an endowment from private company rather than a formal collaborative research or a contract research. As restrictions on the use of time and items of expenditure attached to endowment were relatively small, and it can be reasonably expected that the invention will be exploited by the private company, it worked as an incentive for the faculty to engage in collaboration with industry although the amount of money endowed was generally not too much. And that is the primary cause of a patent application by faculty through private company (Kneller 2003). Until now, the difficulties attached to formal university-industry links have relatively been settled upon; the promotional incentives for university faculty, the processes for subsidies and research support have been simplified with functions for university patent applications. The informal nature of university-industry relations has been subject to a series of reforms yet firms continue to provide contributions suggesting that the informal relationship is continuing. To investigate this thoroughly, it cannot be denied that the informal system has been a good system for Japanese university-industry links. It has been continuously emphasized that the construction of a close relationship between universities and industry is important for the activation of research activities by university faculty.

The Scientific Advisory Council in 1977 correctly identified that for universities quick and rapid patent application, control and *practical use* management is absent. However, policy makers decided prematurely that patents belonging to universities in principle ignoring the informal university-industry links. Until now the university-industry relationship has not been that close and for the future, Japan’s university-industry relations would make a loss.

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